EXHIBIT A
(TRANSLATION)

Confidential! Please seal before sending on!	**Notification of invention** Infineon Technologies AG and/or Associated Company *Already sent in advance via fax to ZT PA* ☐ *If yes - please make sure that the box is ticked.*	Appendix A 2062E50229DE
I/We (Given name and surname of the inventor(s) - further details and signature(s) on the last page) Harald Böttner, Martin Jägle and Axel Schubert	No. of inventors: 3	Date of completion: 6.26.2002

hereby give notification of the invention described in full on the following pages called:

AuBi thin-film solder

I. To the superior of the inventor(s)	Received on:
Mr/Ms Mr Kühlmann CFE PT TC OPTO (Department)	
Please answer the following questions:	
a) When did you receive notification of the invention?	July 5, 2002
b) Is the invention based on publicly sponsored work? X No ☐ Yes, scheme: ______	[signature]
c) Is there an associated internal R&D project? ☐ No X Yes, project: MicroPelt: Infineon Venturers	Statutory time limit starts as of the date received.

Only to be completed for ZT inventions:

Project no.: Title: Core technology:
☐ Development project In the interest of dept.: Contact:
☐ Research project

d) Is registration recommended? ☐ No X Yes Urgency	
Cost to be borne by (organizational unit): Infineon Venture	
X The invention does not relate to our area of interest. The following departments should be asked: Infineon Venture	FO is main user.
07.05.2002 *[signed]* (Date) (Signature of superior)	
II. Due to the statutory time limit, please pass on immediately to: Siemens AG ZT PA (patents department) Site: ______ (E.g.: Mch/M, Erl/S, Bln/N, Khe/R, Pdb) for further actioning.	Received on: *[stamped]* *[stamped]*

Sheet 2/4 File reference of the PA

1. Which technical problem does your invention propose a solution to?
2. How has this problem been solved up until now?
3. In which manner does your invention solve the indicated technical problem (please indicate its advantages)?
4. Wherein lies the inventive step?
5. Embodiment(s) of the invention.

1) Subject of the patent application

The present patent application describes the use of AuBi thin-film solders for utilization in soldered connections and preferably for the manufacture of thermoelectric components such as peltier coolers and thermo-generators.

2) State of the art

See Attachment.

3) Solution of the problem

See Attachment.

4) The inventive object is achieved by the **embodiments 1 to 7** described in the Attachment.

See Attachment.

6. The following attachments are enclosed for further explanation:

___9___ page(s) showing representation(s) of one or more embodiments of the invention;

(if possible the drawings should be prepared in PowerPoint or Designer format)

______ page(s) with additional descriptions (e.g. lab reports, test reports);

______ page(s) of literature describing the state of the art on which the invention is based; *)

______ other documents (e.g. diskettes, particularly with drawings of the embodiments):

*) Please enclose photocopies of all cited publications (articles in full; for books the relevant chapter) with complete bibliographical data.

Sheet 3/4 File reference of the PA

7. Which departments are interested in the invention? Infineon Ventures

8. Has the invention already been tested (performance of tests, fabrication of prototypes)?

X No ☐ Yes, result:

9. For which products is the invention applicable? Thermoelectric components

10. Is application of the invention planned?

☐ No X Yes, at: MicroPelt (Infineon Ventures)

11. Has a product based on the invention been supplied or is its supply planned?

☐ No X Yes, on (estimated): 7.1.2003 : Name of the product: Peltier Cooler

12. Is publication of the invention planned, or has it already been published?

X No ☐ Yes, on (estimated): ________ in book, periodical: ________

13. Is disclosure of the invention to persons outside the company planned or has the invention already been disclosed to persons outside the company?

X No ☐ Yes, on (estimated): ________ to ________

14. You are requested to assess the following criteria to your best ability:

a **Difficulty for competitors to work around the invention**

Equivalent alternatives

☐ Not practically realizable

X Requires effort

☐ Realizable without difficulties

b **Attractiveness of usage to competitors**

Competitor interest

X Exceptional

☐ Average

☐ Minimal

c **Proof of usage by competitors**

Proof of usage

☐ Possible without difficulties

X Complex

☐ Practically impossible

d **In-house usage**

X (Probably) yes

☐ Uncertain

☐ Unlikely

Sheet 4/4 File reference of the PA

15. Personal details of the inventor(s) (Inventors 1-4 to be entered on this sheet. Please enclose an additional sheet for further inventors):

Name	Böttner	Schubert	Jägle	
Name at birth	Böttner	Schubert		
Given name	Harald	Axel	Martin	
APD/personnel no.*)		627672		
Is this your first notification of invention to ZT PA?	☐ Yes X No	☐ Yes X No	☐ Yes X No	☐ Yes ☐ No
Academic grade/title/occupation	Dr. Dipl. Chem.	Dipl. Phys.	Dipl. Phys.	
At the time of invention: student trainee/research student/postgraduate student	☐ Yes Please enclose copy of contract	☐ Yes Please enclose copy of contract	☐ Yes Please enclose copy of contract	☐ Yes Please enclose copy of contract
Activity/post within the company (e.g. lab principal)		Development engineer		
Employer if not Siemens AG	Fh-IPM	Infineon AG	Fh-IPM	
Area		CPS		
Department	KMS	CPS PT TC OPTO	KMS	
Site	Freiburg	MB	Freiburg	
Telephone (office)	0761 8857121	234 23622	0761 8857 345	
Facsimile (office)	0761 8857224	234 24791	0761 8857 224	
E-mail	harald.boettner@ipmk.fhg.de	axel.schubert@infineon.com	jaegle@ipm.fhg.de	
Nationality (if not German)				
Home address: Street, house number	Seilerweg 5	Sommerstr. 25	Dorfstr. 37	
Post code, town/city	79108 Freiburg	81543 Munich	79350 Sexau	
Date of birth	10.17.1949	3.1.1957	1.14.1966	
16. Is the invention a) In your field of work? b) In a different field of work of your employer?	a) X Yes ☐ No b) ☐ Yes ☐ No	a) X Yes ☐ No b) ☐ Yes ☐ No	a) X Yes ☐ No b) ☐ Yes ☐ No	a) ☐ Yes ☐ No b) ☐ Yes ☐ No
17. What is your contribution to the invention?	45%	10%	45%	%
18. Has or will the invention also be registered as a VV?	☐ Yes ☐ No	☐ Yes X No	☐ Yes ☐ No	☐ Yes ☐ No
19. Please give reasons if you see the invention as a free invention:				
20. According to my/our knowledge, no further persons are involved in the invention.	*(signed)* (Signature)	*(signed)* (Signature)	*(signed)* (Signature)	(Signature)

*) Please refer to company pass or pay slip.

AuBi thin-film solder

Harald Böttner, Martin Jägle, Axel Schubert (10%)

Subject of the patent application

The present patent application describes the use of AuBi thin-film solders for utilization in soldered connections and preferably for the manufacture of thermoelectric components such as peltier coolers and thermo-generators.

State of the art

Patent application publication DE 198 45 104 A1 describes in detail methods for manufacturing thermoelectric transducers, manufactured at wafer level in varying embodiments. One substantial core aspect of a number of the embodiments is that components comprising two substrate wafers, coated with the respective complementary n/p materials, are manufactured. A further aspect of this technical teaching is the fact that, in one of the last process steps, both wafers must be soldered to each other in such a manner that the structures of the wafers are opposed to each other. A number of methods have been set out in the above patent application publication in order to achieve this. The only low-temperature solder suitable for this purpose, which must be structurable for applications in the manufacturing of components, indicated here is AuSn. The reason for this is the low soldering temperature which can be achieved hereby and which is required in order to ensure functional capability of the components, and which lies just above the eutectic temperature of 276°C, see Figure 1. AuSn is used as a standard solder in a number of electrical engineering applications, one of the reasons for which is its relatively noble character (high Au content).

Problem solution

One disadvantage of the soldering partner AuSn is the fact that, for use in thin-film technologies, e.g. in the case of sputtered contacts, this material must be manufactured as a special target with the gross composition of the eutectic alloy. It is known of multiple-component targets that they change their composition with time as a result of preferential sputtering of various elements, so that the problem in principle of the change in composition of the sputtered-on thin layer is always present. An analogous problem arises in the case of thermic evaporation from a mixed source. A further significant disadvantage of this solder for the above wafer/wafer bonds also results directly from the phase diagram of AuSn, Figure 1. Starting from the eutectic with 70at% Au, the temperature of the solidus curve increases significantly

with increasing Au content. According to the above patent application publication, Au is the preferred contact partner. Therefore the soldering process is quasi self-stopping because of the partner Au. Process optimization is thus made more difficult. As the soldering process must be performed at preferably low temperatures for protection of the entire component structure, the soldering temperature must not exceed the eutectic temperature of 276°C by much.

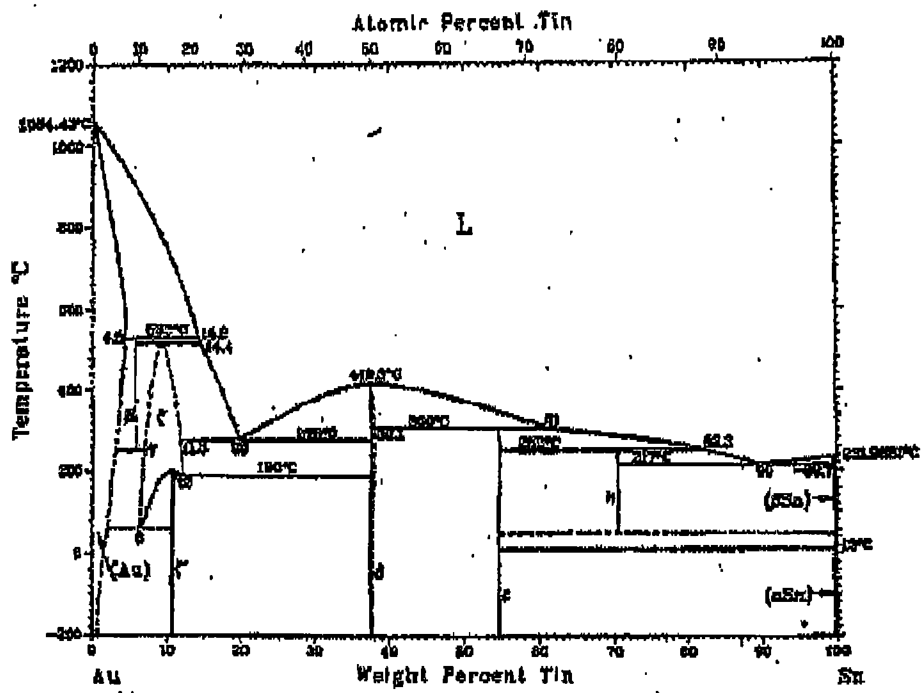

Figure 1: Phase diagram for Au-Sn

For technological further processing, the proportion of the base Sn of 30at% is also a disadvantage. A further disadvantage lies in the fact that, due to the extremely different chemical properties of the elements involved, AuSn films can only be poorly etched by wet chemical means. In addition, during wet chemical etching of AuSn there is always the risk of the formation of finely distributed SnO_2, which usually adheres well. For technological steps which follow on from possible wet etching, contamination with SnO_2 is an incalculable risk. As a consequence of this, AuSn is typically structured by means of a lift-off process. At typical layer thicknesses for such thin-film soldering processes, which are preferably in the region of ~1-2 µm, this is known to be a significant technological problem.

The disadvantages of this behavior are thus evident. The inventive object is therefore to develop a low-temperature solder which:

1. displays a similar eutectic temperature;

2. makes possible the use in elemental form of the components involved in the solder;
3. displays low toxicity;
4. has a similar, noble character;
5. is easy to process and easy to structure;
6. is easy to solder with Au;
7. displays with increasing Au content a low increase in the solidus curve in the vicinity of the eutectic.

The inventive object is achieved from the use of Bi as the soldering partner.

Notes on 1:

"a similar eutectic temperature":

The phase diagram for AuBi, Figure 2, displays the required low eutectic temperature. With 241°C for the eutectic temperature, the conditions are still significantly more advantageous.

Notes on 2:

"makes possible the use in elemental form":

Bi can be used in elemental form.

Notes on 3:

"low toxicity":

When handled normally in elemental form, Bi is non-toxic, and as a result no safety identifications are required according to German regulations.

Notes on 4:

"similar, noble character":

Bi is known as a noble element which naturally occurs in solid form.

Notes on 5:

"easy to process":

Bi is easy to process and etch in thin-film processes.

Notes on 6:

"easy to solder with Au":

This is given according to the inventive embodiments by virtue of the eutectic contact.

Notes on 7:

"with increasing Au content a low increase in the solidus curve must be present":

This corresponds to the information in the phase diagram.

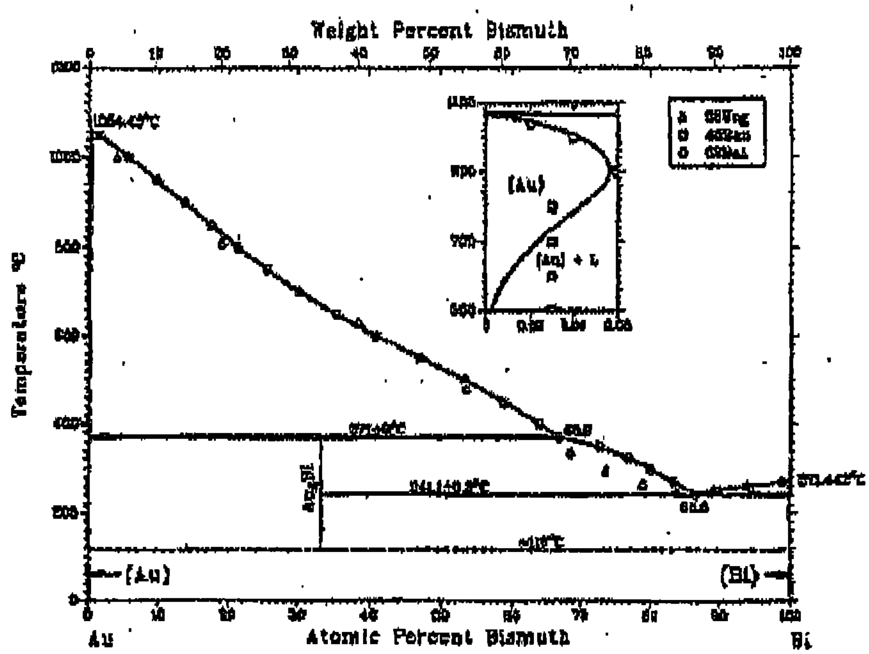

Figure 2: Phase diagram for Au-Bi

For e.g. the manufacture of thin-film thermoelectric components, as also described in the above patent application publication, the manufacturing process described there is simplified significantly. In contrast to AuSn, see above, the soldering partner Bi is easily structurable. No interfering reaction products are formed during wet chemical processes. The soldering process is simplified as a result of the formation of the AuBi eutectic between the Au and Bi layers. The flat solidus curve on the Au-rich side further provides scope for freedom in the design of the soldering process, as no self-stopping soldering process like the one encountered in the case of AuSn comes into play here.

Embodiments:

The following embodiments are used to explain both possible fabrications and applications.

Example 1: Manufacture of a solderable Bi thin-film structure through etching techniques

The manufacture of structured solderable Bi layers is performed according to the standard methods of thin-film technology.

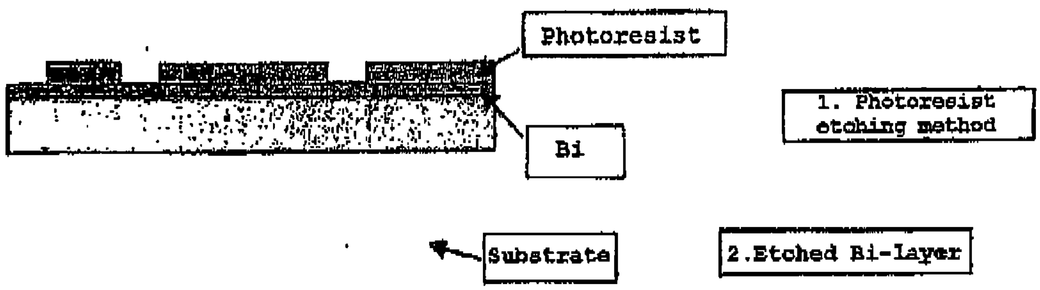

Figure 3: Example 1: Schematic clarification of Bi layers structured through etching

Example 1, Figure 3 shows the manufacture of Bi layers by means of etching techniques, wherein both wet and dry techniques can be applied. In analogous fashion it is possible to manufacture Au layers (not shown). The thicknesses for both materials are in the range from a few 100 nm to a few µm, preferably around 1-2 µm. In terms of their properties and layer thickness, the materials of the auxiliary layers for the technical processes of etching or lift-off are governed by the requirements of the soldering materials and the structuring technology used. Preferably, photoresist can be used for both soldering partners Au and Bi and for both mentioned etching technologies.

Example 2: Manufacture of a solderable Bi thin-film structure through lift-off techniques

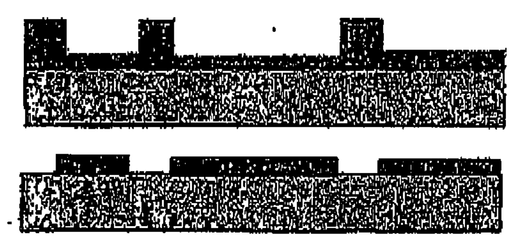

Figure 4: Example 2: Schematic representation of Bi layers structured through lift-off

Example 2, Figure 4, schematically shows the manufacture by means of a lift-off process. The thicknesses for both materials and technologies are in the range from a few 100 nm to a few µm, preferably around 1-2 µm. In terms of their properties and layer thickness, the materials of the auxiliary layers for the technical processes of etching or lift-off are governed by the

requirements of the soldering materials and the structuring technology used. Preferably, photoresist can be used for the lift-off process for both soldering partners Au and Bi and for the standard physical coating techniques.

Example 3: Embodiment of the eutectic AuBi thin-film soldered connection

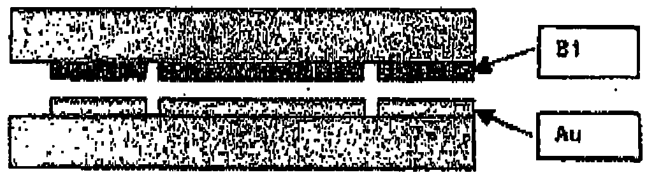

Figure 5: Example 3: Schematic diagram of a eutectic soldered connection with structured soldering metals during the adjustment before the soldering process

Figure 5 schematically shows an embodiment of the eutectic AuBi thin-film soldered connection with structured metal layers directly before the soldering process.

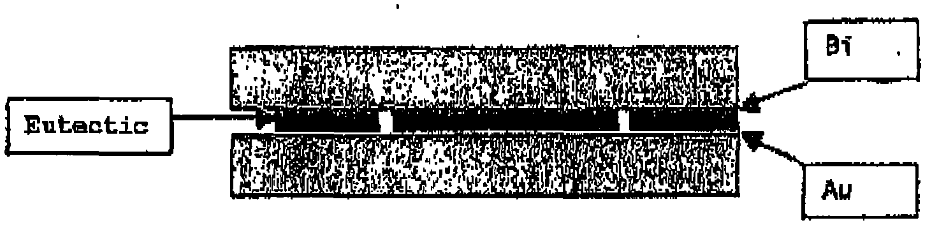

Figure 6: Example 3: Schematic diagram of the layer structure after the soldering process

Example 3, Figure 6, schematically shows the embodiment of the eutectic AuBi thin-film soldered connection with structured metal layers after formation of the eutectic. The layer structure shown in Figure 6 is an important feature of the inventive eutectic soldered connection. After the soldering process, the eutectic is formed between still remaining portions of unused source material. In some cases an interdiffusion contact made of Au/Bi can be used (not shown here) as a pre-stage.

Similarly to the case of AuSn, it is further also possible through the setting of corresponding requirements during the respective physical coating method to preset the eutectic composition of Au in relation to Bi as a physical mixture and to thereby use it as an additional solder layer in some cases (not shown).

Example 2, Figure 4, schematically shows the manufacture by means of a lift-off process. The thicknesses for both materials and technologies are in the range from a few 100 nm to a few µm, preferably around 1-2 µm. In terms of their properties and layer thickness, the materials of the auxiliary layers for the technical processes of etching or lift-off are governed by the requirements of the soldering materials and the structuring technology used. Preferably, photoresist can be used for the lift-off process for both soldering partners Au and Bi and for the standard physical coating techniques.

Example 3: Embodiment of the eutectic AuBi thin-film soldered connection

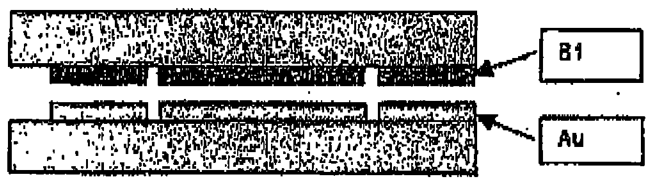

Figure 5: Example 3: Schematic diagram of a eutectic soldered connection with structured soldering metals during the adjustment before the soldering process

Figure 5 schematically shows an embodiment of the eutectic AuBi thin-film soldered connection with structured metal layers directly before the soldering process.

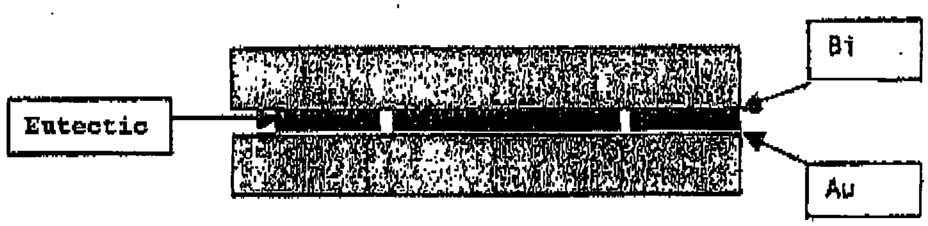

Figure 6: Example 3: Schematic diagram of the layer structure after the soldering process

Example 3, Figure 6, schematically shows the embodiment of the eutectic AuBi thin-film soldered connection with structured metal layers after formation of the eutectic. The layer structure shown in Figure 6 is an important feature of the inventive eutectic soldered connection. After the soldering process, the eutectic is formed between still remaining portions of unused source material.

In some cases an interdiffusion contact made of Au/Bi can be used (not shown here) as a pre-stage.

Similarly to the case of AuSn, it is further also possible through the setting of corresponding requirements during the respective physical coating method to preset the eutectic composition of Au in relation to Bi as a physical mixture and to thereby use it as an additional solder layer in some cases (not shown).

Example 4: Embodiment of the eutectic soldered connection in a component which has additional functional layers

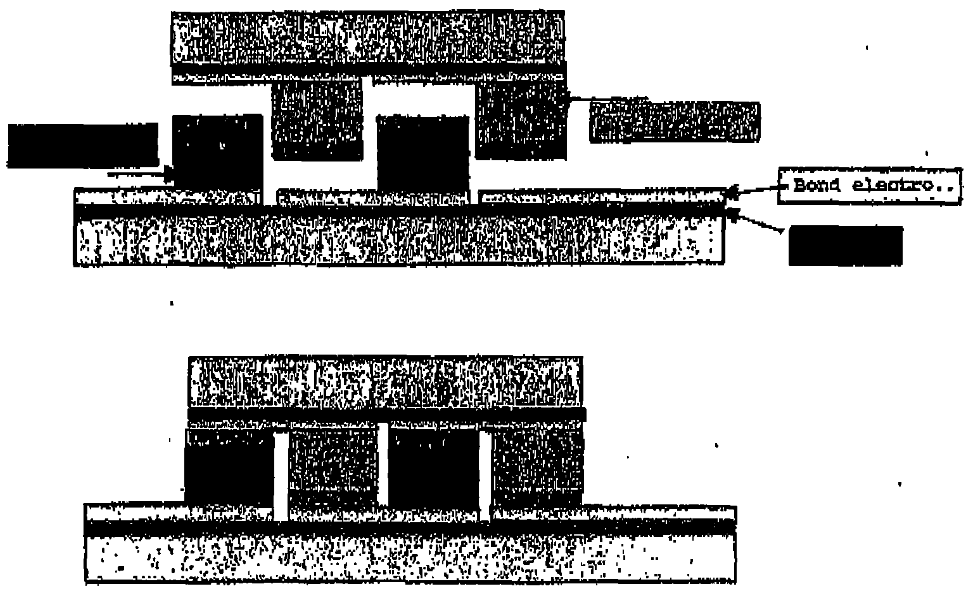

Figure 7: Example 4: Embodiment of the eutectic soldered connection in a component

Example 4, Figure 7, schematically shows an embodiment of the eutectic AuBi thin-film soldered connection in a thermoelectric component having two complementary n/p wafers before - upper picture - and after - lower picture - soldering. The layout and structure of the complementary n/p wafers correspond to an embodiment in the abovementioned patent application publication. Figure 7 shows the arrangement of metal layers for execution of the eutectic soldering. Further necessary metal layers for layer adhesion and/or diffusion barriers do not form part of this technical teaching. The arrangement of metal layers given in Example 4 having Au on the substrate and Bi on the functional thermoelectric layer can also be applied in the complementary arrangement.

As a further development of Example 5, Figure 8 schematically shows two embodiments, Example 6, for use of the solder without electrical functionality. Here, the solder is used for the bonding-on of a fluidic cell and/or a capacitative moisture sensor, wherein both possible layer sequences for the soldering metals can also be used for this purpose. The IDK structure is tilted into the paper plane for ease of identification. In this example, the use of the inventive solder is shown schematically for the thermostating of a fluidic cell on a peltier cooler.

Here, both the inner bonding quality of the eutectic connection and the good thermal coupling to the peltier heat sink are exploited. An electric usage of the soldered connection is not given here.

Example 7: Eutectic solder as bond contact with electrical functionality for laser cooling (usage in submount technologies) and without electrical functionality for bonding on heat sinks

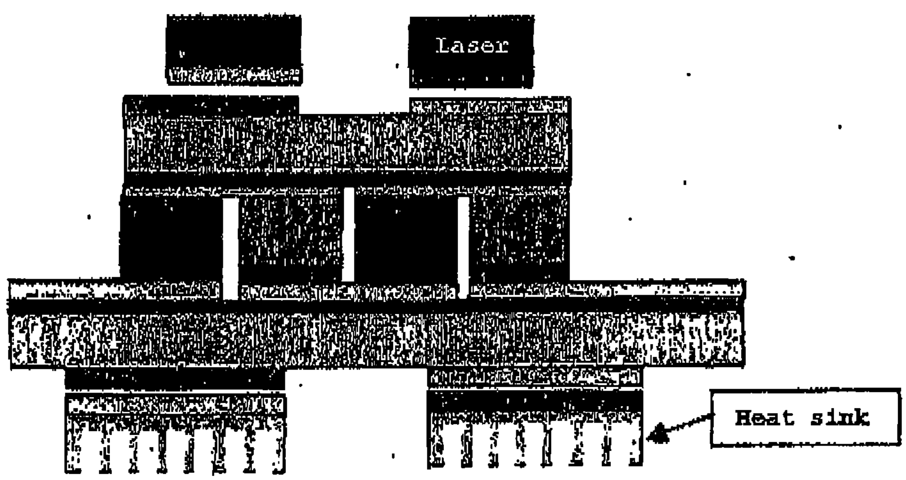

Figure 9: Example 7: Embodiment of the eutectic solder with electrical functionality for laser cooling and without electrical functionality for bonding on heat sinks

As a further development of Example 5, Figure 9, Example 7, schematically shows the simultaneous usage of the solder with and without electrical functionality. Here, in a further development of Example 5, the solder is used to bond on heat sinks, wherein both of the possible layer sequences for the soldering metals can also be used for this purpose, see Figure 9. The heat sink can comprise an Si-wafer which is (100) anisotropically etched with KOH. In this embodiment, both the inner bonding quality of the eutectic connection

and the good thermal coupling to the peltier heat sink are exploited. An electric usage is not given here.

Claims:

Au/Bi eutectic thin-film solders formed from the elements

Au/Bi eutectic thin-film solders formed from the eutectic composition

Au/Bi eutectic thin-film solders, manufactured by means of PVD methods

Au/Bi eutectic thin-film solders, manufactured having one layer comprising the physical mixture of the involved elements at the concentration ratios of the eutectic

Au/Bi eutectic thin-film solders having layer thicknesses of 100 nm to a few µm

Au/Bi eutectic thin-film solders having layer thicknesses of preferably 1-2 µm

Solder structure having a eutectic phase with and without remaining source layers

Solder structure not having a eutectic phase, instead having an interdiffusion layer (Au/Bi) with and without remaining source layers

Au/Bi thin-film solders having an electrical functionality

Au/Bi thin-film solders having a thermal functionality

Au/Bi thin-film solders having an adhesive functionality

Au/Bi thin-film solders for the construction of electronic components

Au/Bi thin-film solders for the construction of thermoelectric components

Au/Bi thin-film solders for the both-sided utilization of a substrate

Au/Bi thin-film solders for utilization in submount technologies